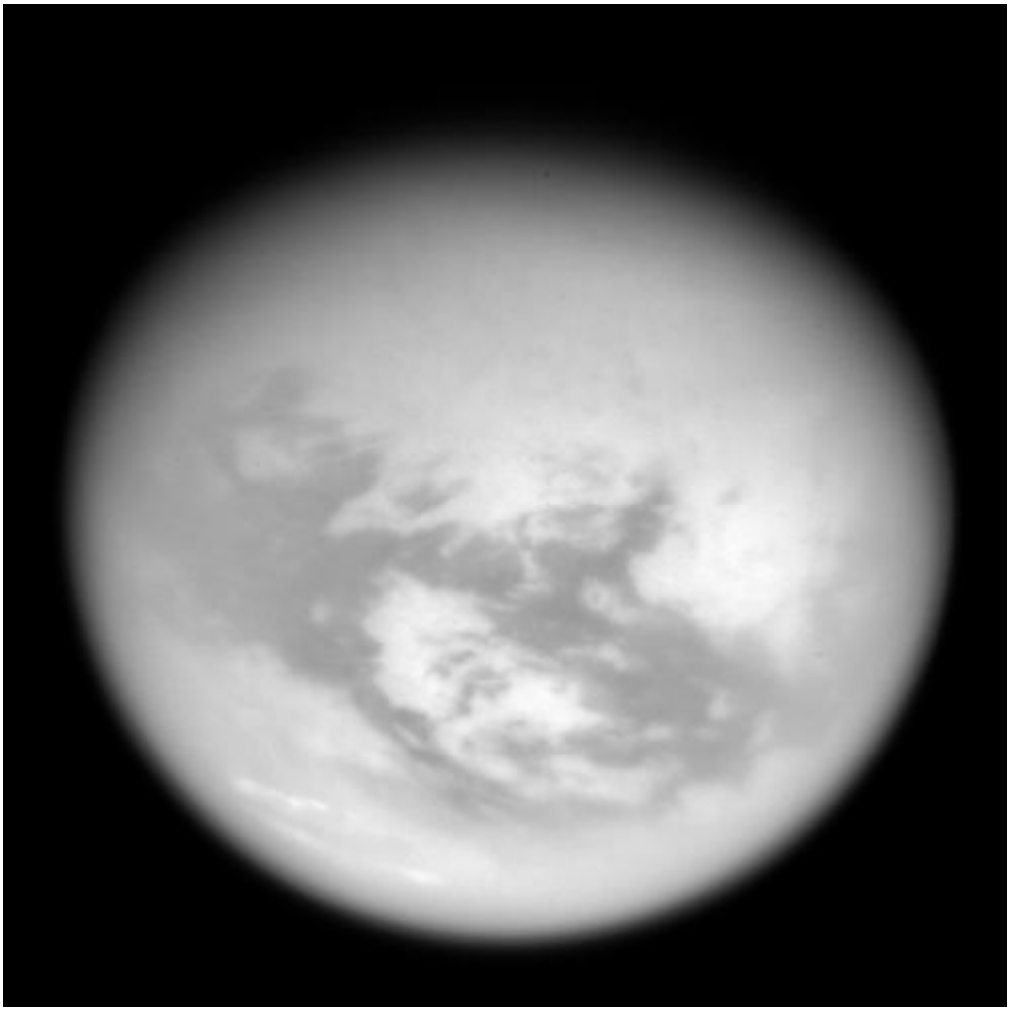
C A S S I N I



T I T A N **0 5 4 T I (T 3 9)** MISSION DESCRIPTION

Dec 20 2007

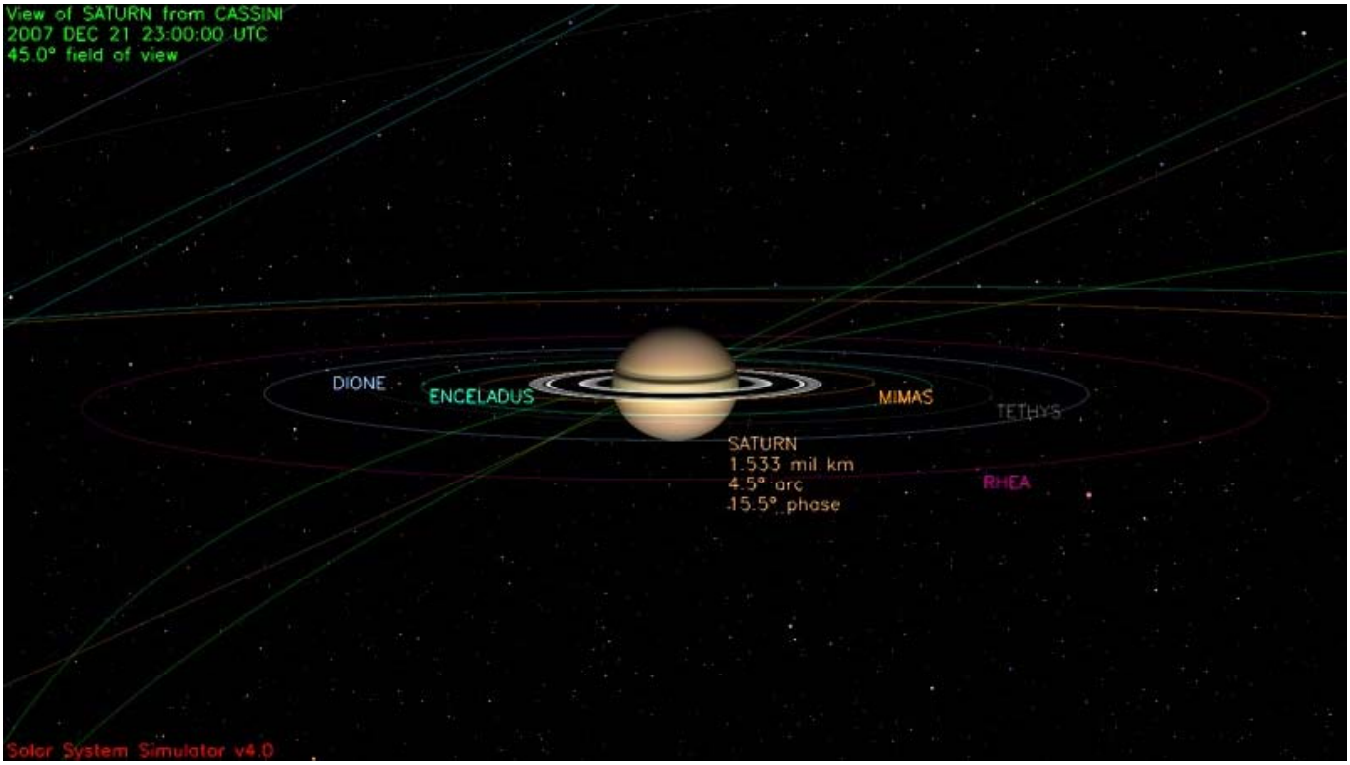
Jet Propulsion Laboratory
California Institute of Technology

Cover image: Weather Without Water: Bright mid-latitude clouds near the bottom of this view hint at the ongoing cycling of methane on Titan. These cloud streaks are near the same latitude as similar clouds observed above different longitudes on Titan. The view is centered on Titan's trailing hemisphere, over the 1,700 kilometer (1,050 mile) wide bright region known as Adiri. North on Titan (5,150 kilometers, or 3,200 miles across) is up and rotated 15 degrees to the right. This view was created by combining multiple images taken using a combination of spectral filters sensitive to wavelengths of infrared light centered at 939 and 742 nanometers The images were taken with the Cassini spacecraft wide-angle camera on May 13, 2007 at a distance of approximately 104,000 kilometers (65,000 miles) from Titan. Image scale is 12 kilometers (8 miles) per pixel. Due to scattering of light by Titan's hazy atmosphere, the sizes of surface features that can be resolved are a few times larger than the actual pixel scale. Credit: NASA/JPL/Space Science Institute

1.0 OVERVIEW

Almost sixteen days after Cassini's Titan-38 flyby, the spacecraft returns for the Cassini mission's fortieth targeted encounter with Titan. The closest approach to Titan occurs on Thursday, Dec. 20, at 2007-354T22:57:55 spacecraft time at an altitude of 970 kilometers (~602 miles) above the surface and at a speed of 6.3 kilometers per second (14,000 mph). The latitude at closest approach is 70 degrees S and the encounter occurs on orbit number 54.

This encounter is set up with two maneuvers: an apoapsis maneuver on December 13, and a Titan approach maneuver, scheduled for December 17. T39 is the fourth in a series of outbound encounters that will last until the end of the prime mission, and occurs less than two days after Saturn closest approach. This is the fourth in a series of seven Titan southern hemisphere encounters.



ABOUT TITAN

If Titan were a planet, it would likely stand out as the most important planet in the solar system for humans to explore. Titan, the size of a terrestrial planet, has a dense atmosphere of nitrogen and methane and a surface covered with organic material. It is Titan that is arguably Earth's sister world and the Cassini-Huygens mission considers Titan among its highest priorities.

Although it is far colder and lacks liquid water, the chemical composition of Titan's atmosphere resembles that of early Earth. This, along with the organic chemistry that takes place in Titan's atmosphere, prompts scientists to believe that Titan could provide a laboratory for seeking insight into the origins of life on Earth. Data from the Huygens probe, which touched down on Titan's surface in January 2005, and the Cassini orbiter has shown that many of the processes that occur on Earth also apparently take place on Titan – wind, rain, volcanism, tectonic activity, as well as river channels, and drainage patterns all seem to contribute in shaping Titan's surface. However, at an inhospitable -290 degrees Fahrenheit (-179 degrees Celsius), the chemistry that drives these processes is fundamentally different from Earth's. For example it is methane that performs many of the same functions on Titan that water does on Earth.

The Huygens probe landed near a bright region now called Adiri, and photographed light hills with dark river beds that empty into a dark plain. It was believed that this dark plain could be a lake or at least a muddy material, but it is now known that Huygens landed in the dark region, and it is solid. Scientists believe it only rains occasionally on Titan, but the rains are extremely fierce when they come.

Only a small number of impact craters have been discovered. This suggests that Titan's surface is constantly being resurfaced by a fluid mixture of water and possibly ammonia, believed to be expelled from volcanoes and hot springs. Some surface features, such as lobate flows, appear to be volcanic structures. Volcanism is now believed to be a significant source of methane in Titan's atmosphere. However, there are no oceans of hydrocarbons as previously hypothesized. Dunes cover large areas of the surface.

The existence of oceans or lakes of liquid methane on Saturn's moon Titan was predicted more than 20 years ago. Radar and imaging data from Titan flybys have provided convincing evidence for large bodies of liquid. With Titan's colder temperatures and hydrocarbon-rich atmosphere, these lakes and seas most likely contain a combination of liquid methane and ethane (both hydrocarbons), not water.

The Cassini-Huygens mission, using wavelengths ranging from ultraviolet to radio, is methodically and consistently revealing Titan and answering long-held questions regarding Titan's interior, surface, atmosphere, and the complex interaction with Saturn's magnetosphere. While many pieces of the puzzle are yet to be found, with each Titan flyby comes a new data set that furthers our understanding of this world as we attempt to constrain scenarios for the formation and evolution of Titan and its atmosphere.

1.1 TITAN-39 SCIENCE HIGHLIGHTS

- **RADAR** uses this opportunity to obtain South Pole coverage, including the first SAR coverage south of 70 degrees south. The inbound leg features radiometry of unique terrain at high latitudes, scatterometry of Titan's southeast terrain, altimetry, and low rate SAR. Outbound observations include radiometry of unique northwestern terrain contiguous with that to be observed on the T43 flyby and scatterometry near the Huygens landing site. RADAR will return to the south pole area in the proposed extended mission, two years after this flyby; this allows the science team to look for changes over time; for instance, are Titan's lakes filling up?
- **ISS** monitors for surface and atmosphere changes of the bright area just to the north of the Adiri region, and it will be attempting to see surface color variations and monitoring limb hazes,. The instrument will also perform a full disk color sequence at 1.4 kilometer/pixel, and will do spectrophotometric low phase angle measurements of Rhea.
- **CIRS** will obtain information on trace constituents in Titan's stratosphere and stratospheric temperatures. Vertical temperature and compositional profiles will be obtained via limb measurements**.**
- **VIMS** will create a regional and global map for continued monitoring of cloud formation and evolution.
- **MAG**: T39 is a very close flyby (970 kilometers) over the southern polar region, passing through the outer flank. Good outer flank (away from Saturn) flybys have been missing until now. The outer flank feature will be an aspect of all coming flybys.

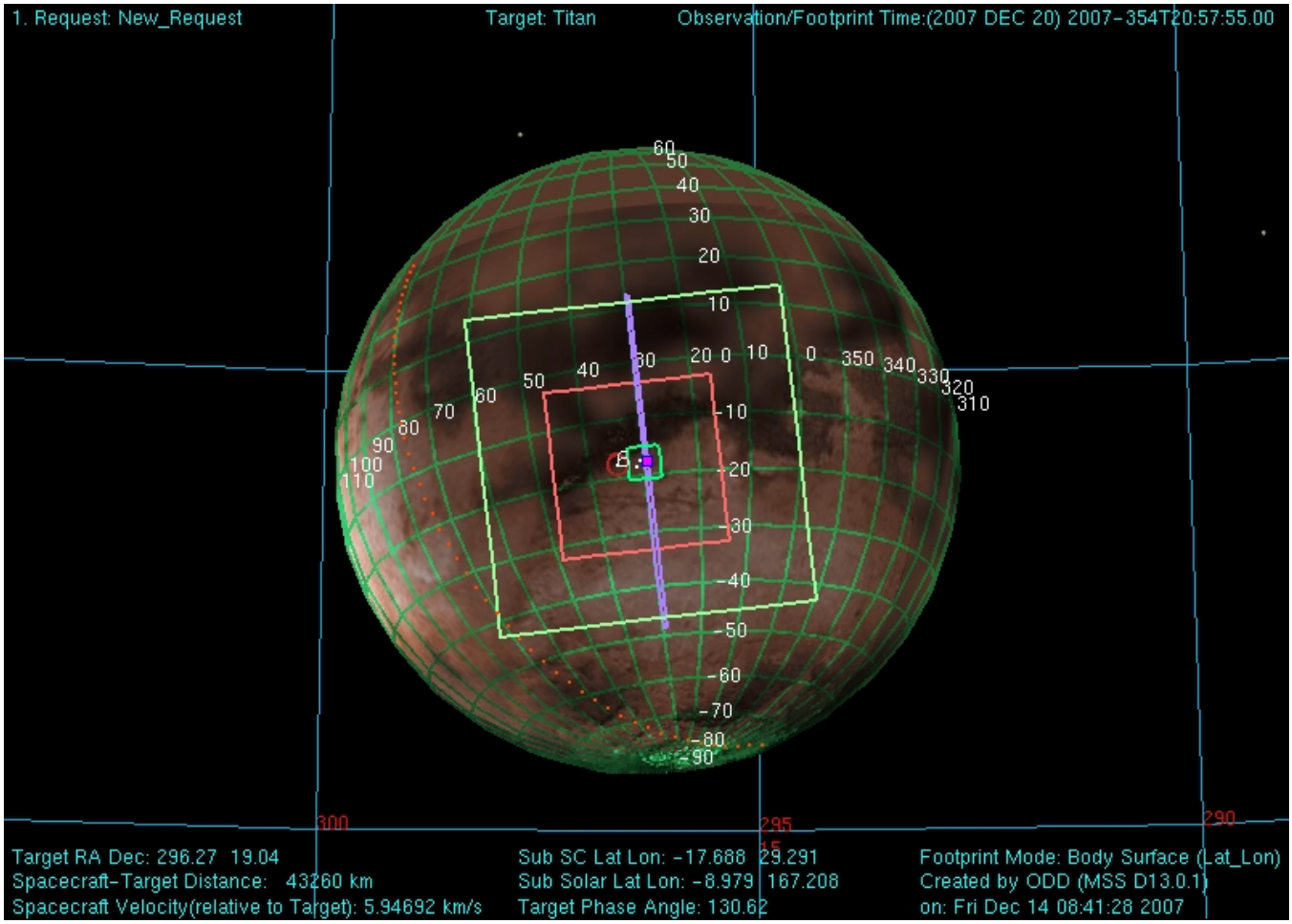
1.2 SAMPLE SNAPSHOTS

Three views of Titan from Cassini before, during, and after closest approach to Titan are shown below. The views are oriented such that the direction towards the top of the page is aligned with the Titan North Pole. The optical remote sensing instruments' fields of view are shown assuming they are pointed towards the center of Titan. The sizes of these fields of view vary as a function of the distance between Cassini and Titan. A key for use in identifying the remote sensing instruments fields of view in the figures is listed at the top of the next page.

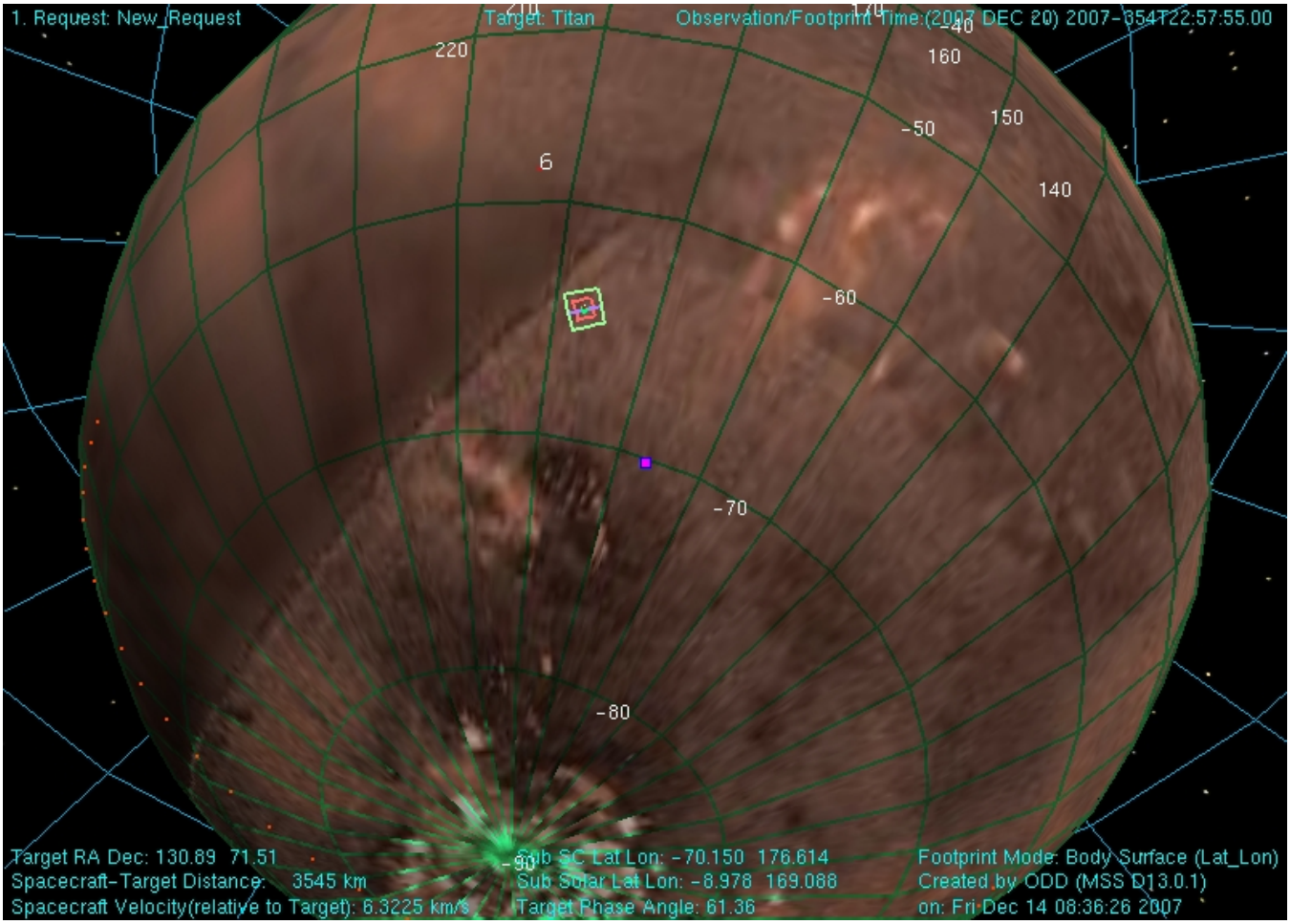
Key to ORS Instrument Fields of View in Figures

Instrument Field of View	Depiction in Figure
ISS WAC (imaging wide angle camera)	Largest square
VIMS (visual and infrared mapping spectrometer)	Next largest pink square
ISS NAC (imaging narrow angle camera)	Smallest green square
CIRS (composite infrared spectrometer) – Focal Plane 1	Small red circle near ISS_NAC FOV
UVIS (ultraviolet imaging spectrometer)	Vertical purple rectangle centered within largest square

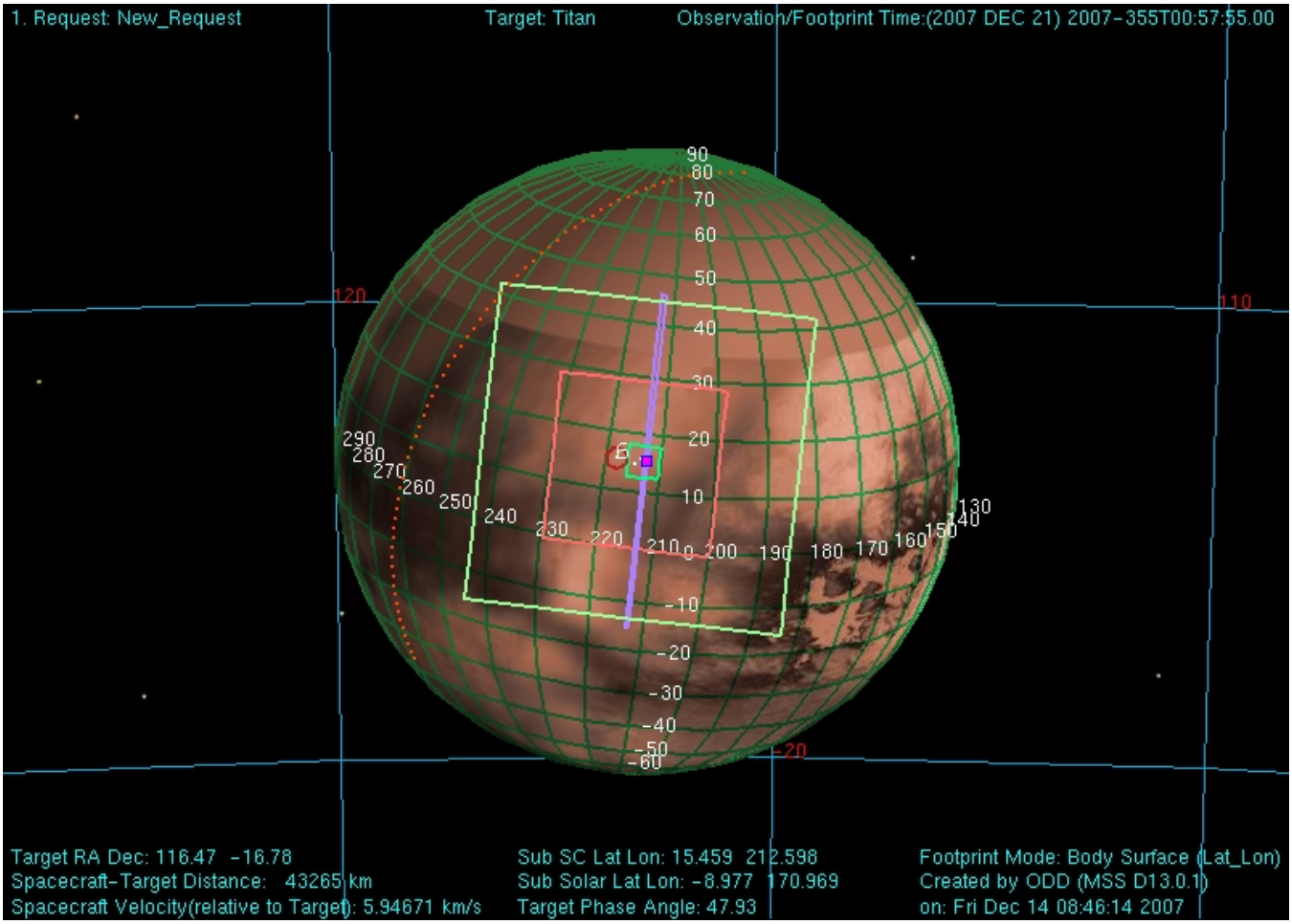
View of Titan from Cassini two hours before Titan-39 closest approach



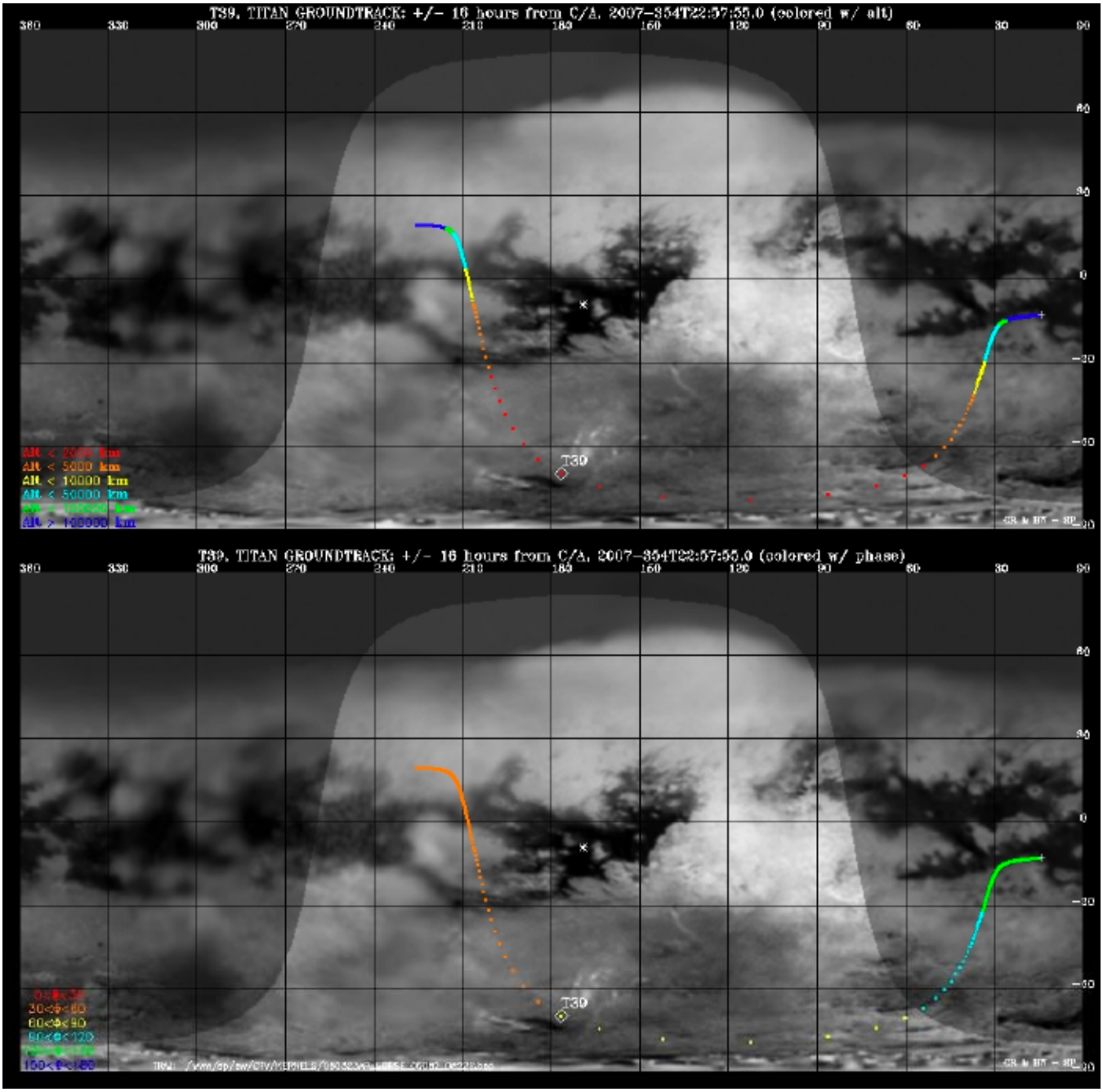
View of Titan from Cassini at Titan-39 closest approach



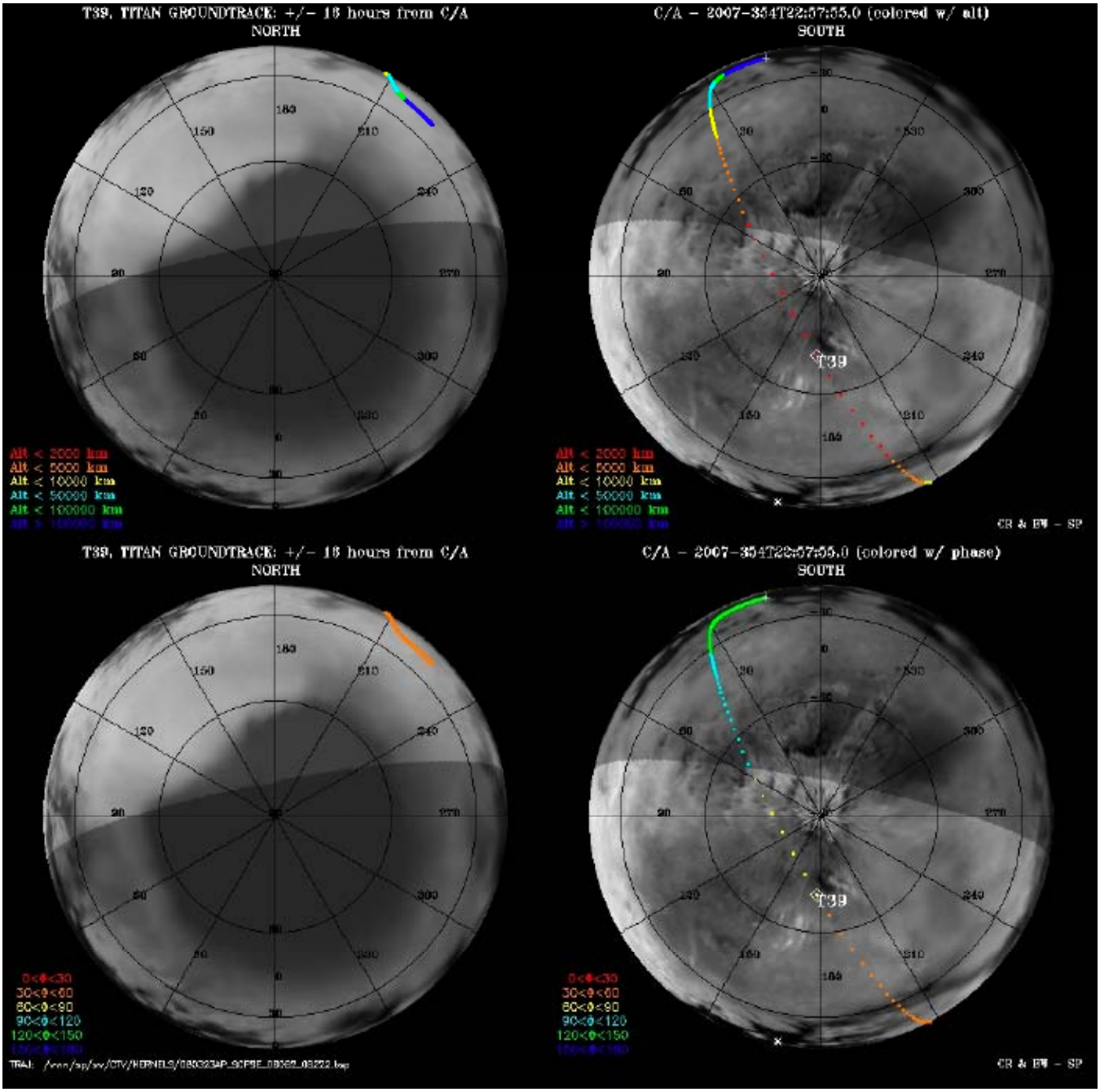
View of Titan from Cassini two hours after Titan-39 closest approach



Titan Groundtracks for T39: Global Plot



Titan Groundtracks for T39: Polar Plot



The T39 timeline is as follows:

Cassini Titan-39 Timeline - December 2007

Colors: yellow = maneuvers; blue = geometry; pink = T39-related; green = data playbacks

Orbiter UTC	Ground UTC	Pacific Time	Time wrt T39	Activity	Description
348T16:00:00	Dec 14 17:14	Fri Dec 14 09:14 AM	T39-06d07h	Start of Sequence S36	Start of Sequence which contains Titan-38
351T23:16:00	Dec 18 00:30	Mon Dec 17 04:30 PM	T39-02d24h	OTM #139 Prime	Titan-38 targeting maneuver.
353T03:35:36	Dec 19 04:49	Tue Dec 18 08:49 PM	T39-01d19h	Descending Ring Plane Crossing	
353T05:04:29	Dec 19 06:18	Tue Dec 18 10:18 PM	T39-01d18h	Saturn Periapse	Saturn periapse, R = 3.0 Rs, lat = -13 deg, phase = 150 deg
353T06:46:00	Dec 19 08:00	Wed Dec 19 12:00 AM	T39-01d16h	OTM #139 Backup	
354T08:16:00	Dec 20 09:30	Thu Dec 20 01:30 AM	T39-14h41m	Start of the TOST segment	
354T08:16:00	Dec 20 09:30	Thu Dec 20 01:30 AM	T39-14h41m	Turn cameras to Titan	
354T08:46:00	Dec 20 10:00	Thu Dec 20 02:00 AM	T39-14h11m	Deadtime	16 minutes 55 seconds long; used to accommodate changes in flyby time
354T09:02:55	Dec 20 10:16	Thu Dec 20 02:16 AM	T39-13h55m	Titan atmospheric Observations-VIMS	Cloud Map
354T13:57:55	Dec 20 15:11	Thu Dec 20 07:11 AM	T39-09h00m	Titan atmospheric observations-CIRS	Obtain vertical profiles of temperatures in Titan's stratosphere.
354T17:51:55	Dec 20 19:05	Thu Dec 20 11:05 AM	T39-05h06m	New waypoint	
354T18:12:55	Dec 20 19:26	Thu Dec 20 11:26 AM	T39-04h45m	RADAR Observations	Inbound radiometry of unique terrain at high latitudes contiguous with T43.
354T21:27:55	Dec 20 22:41	Thu Dec 20 02:41 PM	T39-01h30m	RADAR Observations	Scatterometry
354T22:05:55	Dec 20 23:19	Thu Dec 20 03:19 PM	T39-00h52m	Transition to thruster control	
354T22:27:55	Dec 20 23:41	Thu Dec 20 03:41 PM	T39-00h30m	RADAR Observations	Altimetry observations
354T22:42:55	Dec 20 23:56	Thu Dec 20 03:56 PM	T39-00h15m	RADAR Observations	Low rate SAR
354T22:50:55	Dec 21 00:04	Thu Dec 20 04:04 PM	T39-00h07m	RADAR Observations	High rate SAR
354T22:57:55	**Dec 21 00:11**	**Thu Dec 20 04:11 PM**	**T39+00h00m**	**Titan-39 Flyby Closest Approach Time**	**Altitude = 970 km (602 miles), speed = 6.3 km/s (14,000 mph); 61 deg phase at closest approach**
354T22:57:55	Dec 21 00:11	Thu Dec 20 04:11 PM	T39+00h00m	RADAR and INMS observations	SAR
355T00:15:06	Dec 21 01:29	Thu Dec 20 05:29 PM	T39+01h18m	Ascending Ring Plane Crossing	
354T23:12:55	Dec 21 00:26	Thu Dec 20 04:26 PM	T39+00h15m	RADAR Observations	Altimetry observations
354T23:27:55	Dec 21 00:41	Thu Dec 20 04:41 PM	T39+00h30m	Transition off of thruster control	
354T23:51:55	Dec 21 01:05	Thu Dec 20 05:05 PM	T39+00h54m	RADAR Observations	Scatterometry observations
355T00:29:55	Dec 21 01:43	Thu Dec 20 05:43 PM	T39+01h32m	RADAR Observations	Radiometry
355T03:42:55	Dec 21 04:56	Thu Dec 20 08:56 PM	T39+04h45m	New waypoint	
355T04:02:55	Dec 21 05:16	Thu Dec 20 09:16 PM	T39+05h05m	Titan atmospheric observations-CIRS	Obtain information on trace constituents in Titan's stratosphere. Integrate on limb at two positions.
355T07:57:55	Dec 21 09:11	Fri Dec 21 01:11 AM	T39+09h00m	Titan atmospheric observations-CIRS	Obtain information on CO, HCN, CH4. Integrate on disk at airmass 1.5--2.0.
355T09:57:55	Dec 21 11:11	Fri Dec 21 03:11 AM	T39+11h00m	Titan surface and atmospheric obserations-ISS	monitoring for surface/atmosphere changes; attempt to see surface color variations; monitor limb hazes,
355T11:57:55	Dec 21 13:11	Fri Dec 21 05:11 AM	T39+13h00m	Titan surface observations-VIMS	Regional Map
355T12:57:55	Dec 21 14:11	Fri Dec 21 06:11 AM	T39+14h00m	Rhea surface observations-ISS	Rhea north-polar spectrophotometry
355T14:27:55	Dec 21 15:41	Fri Dec 21 07:41 AM	T39+15h30m	Titan surface observations-VIMS	Global Map
355T23:12:55	Dec 22 00:26	Fri Dec 21 04:26 PM	T39+01d00h	Deadtime	14 minutes 05 seconds long; used to accommodate changes in flyby time
355T23:27:00	Dec 22 00:41	Fri Dec 21 04:41 PM	T39+01d01h	Turn to Earth-line	
355T23:57:00	Dec 22 01:11	Fri Dec 21 05:11 PM	T39+01d01h	Playback of T39 Data	Madrid 70 arrayed

The T39 playback timelines have not been included in this version.